Modeling Air Quality Effects of NOx and PM Emissions from Backup Diesel Generators

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Study Goals

- Use Air Quality Models to assess possible health effects BUGs emissions.
- Model a variety of BUGs activity scenarios.
- Focus on Population Exposure Assessment and effects on O3 attainment plans.

Selection of Models

- Use non-reactive dispersion model to assess local effects of primary emissions:
  - Focus on toxic/PM modeling.
  - Use the Industrial Source Complex Model (ISC)
- Regional air quality modeling
  - Focus on BUGs NOx emissions effects on ozone.

Pollutants and Scale of Domain

- Modeling Scale
  - Local scale (1 km)
  - Urban and Regional scales (10 to 1000 km)
- Pollutants
  - Primary pollutants
    - NO_2 and diesel particulates
  - Secondary pollutants
    - Ozone
    - Secondary Fine Particulates
    - Visibility

Local Scale Concerns

- Health Effects
  - Acute (Nitrogen Dioxide)
    - 1-Hour SAAQS = 0.25 ppm
  - Chronic (Nitrogen Dioxide)
    - Annual NAAQS = 0.053 ppm
    - Health Effects
  - Cancer Risk (Diesel Particulate)
    - One in a million
    - Ten in a million
  - Direct Mortality not estimated:
    - Lack of consensus on risk
    - However, Lloyd and Cackette (2001) review raises concern

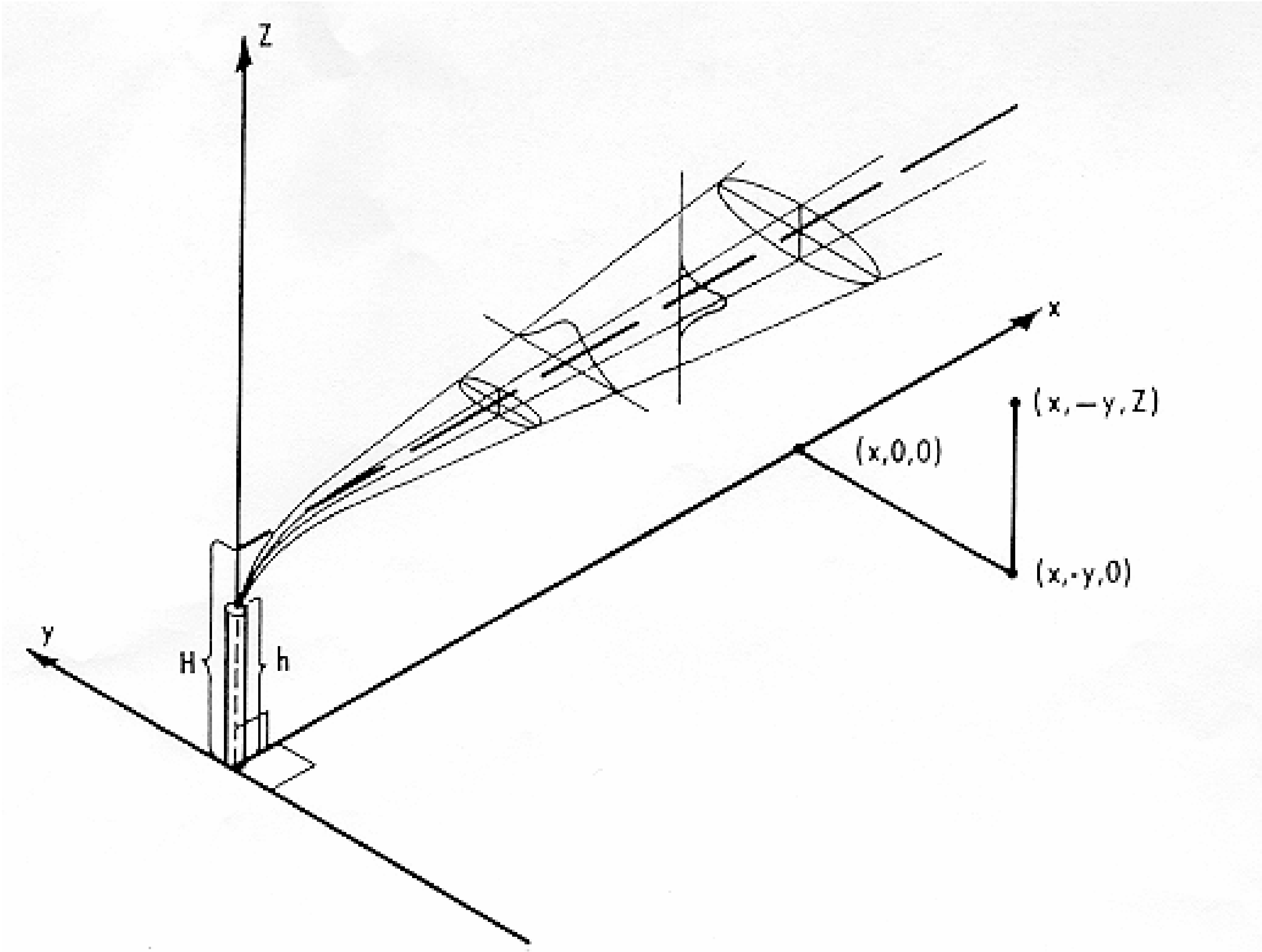
Urban & Regional Scale Concerns

- SAAQS & NAAQS for O3
  - 1 hour O3 average
    - 90 ppb SAAQS & 120 ppb NAAQS
  - 8 hour O3 average
    - NAAQS = 80 ppb
  - Fine Particulates
    - 15 ug/m^3 daily & 65 ug/m^3 annual
  - Visibility and Regional Haze
    - One deciview = 10% change in visual range
  - Nitrate Deposition and Fertilization

Selection of Dispersion Model

- Industrial Source Complex model
  - ISCST VERSION 3 Model
  - Local scale dispersion Gaussian dispersion model
  - Used site specific meteorology data
  - Newest version is AERMOD

ISC is a Gaussian Plume Model



Dispersion Modeling Approach

- Systematic evaluation of parameters that effect surface concentrations for a **generic** BUG installation.
- Model two specific sites using actual meteorology and population data.

Modeling

Generic BUGs Assessment

- Evaluated effects of several parameters on ground level exposure:
  - BUG size and emissions rates
  - Stack height and plume rise
  - Met stability class
  - Effects of surround buildings and downwash
- Exposure can be reduced by careful site selection.

Specific Site Analysis

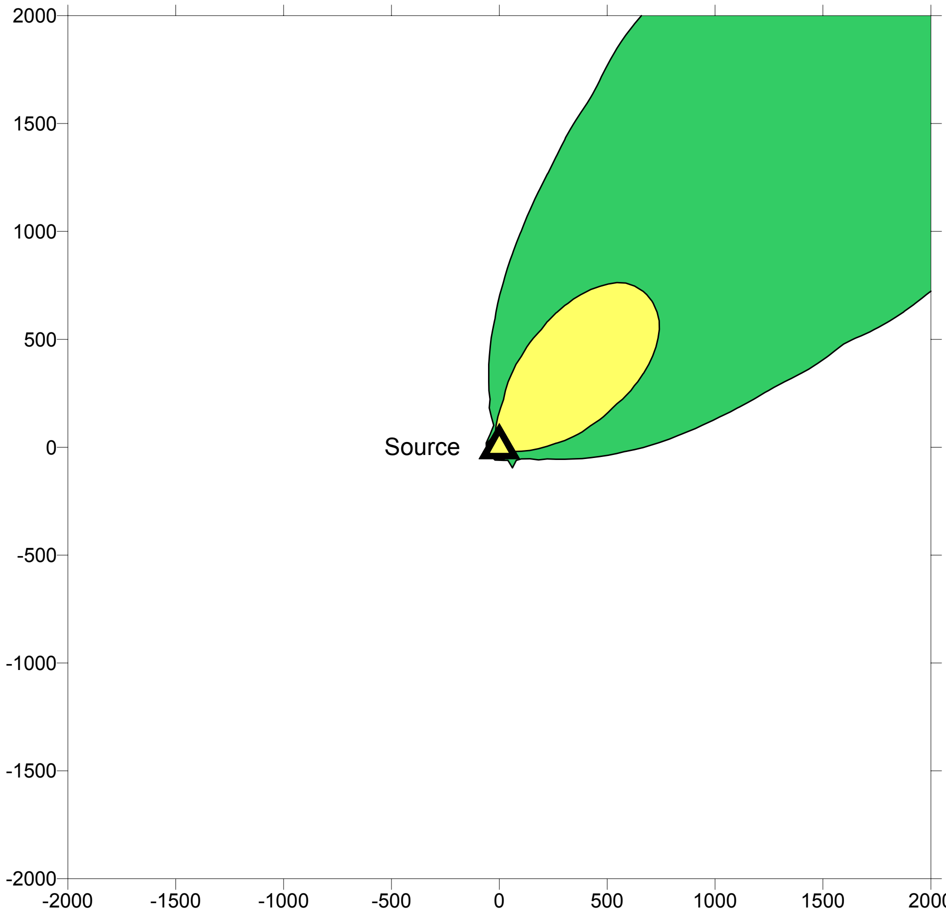
- West Los Angeles Site and Burbank site
- Used observed meteorology data at these sites.
- Modeled annual exposure for several BUG configurations.
- Used population data to assess risk.

Modeling

Cancer Risk Isopleths

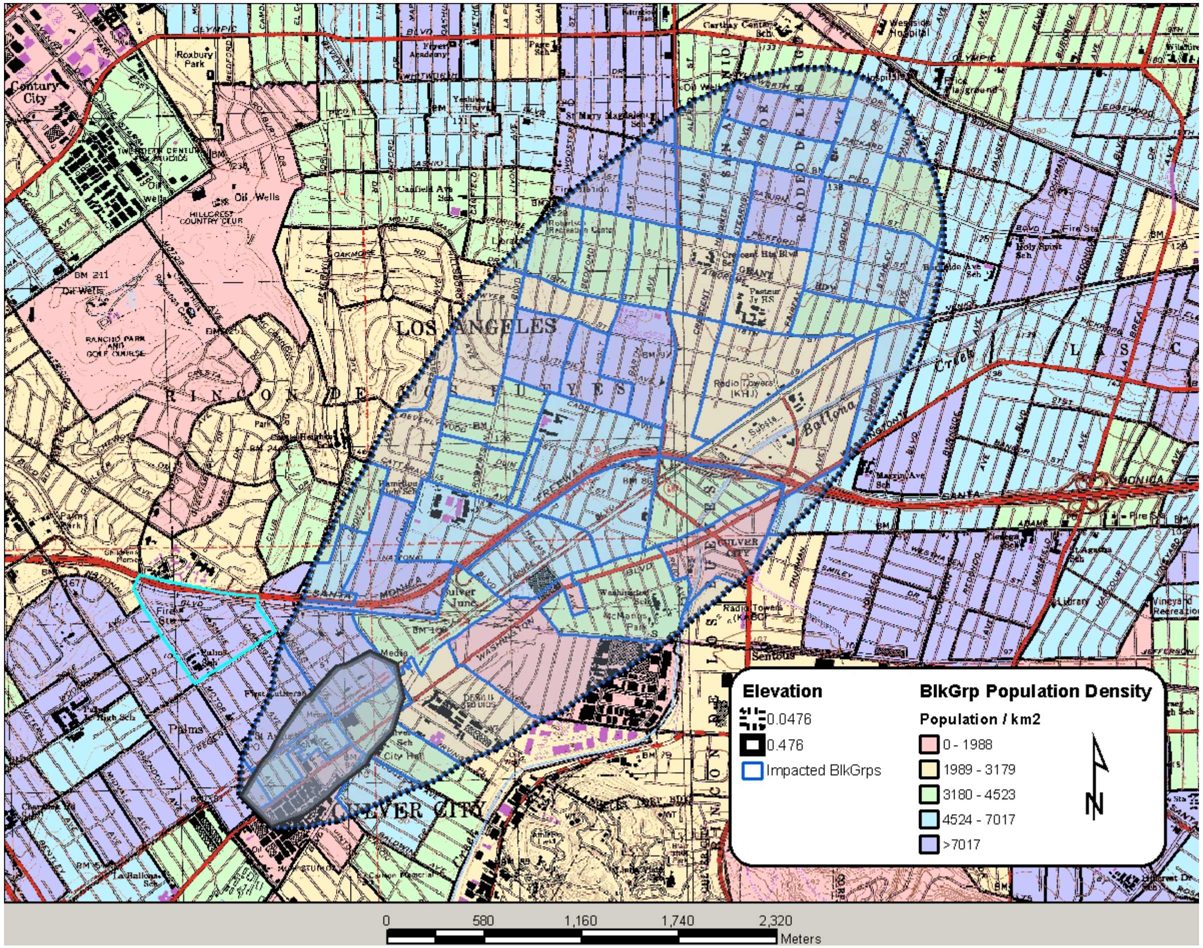
One and Ten in a Million

- Big
- Downwash
- Urban
- 8-Hour
- West Los Angeles



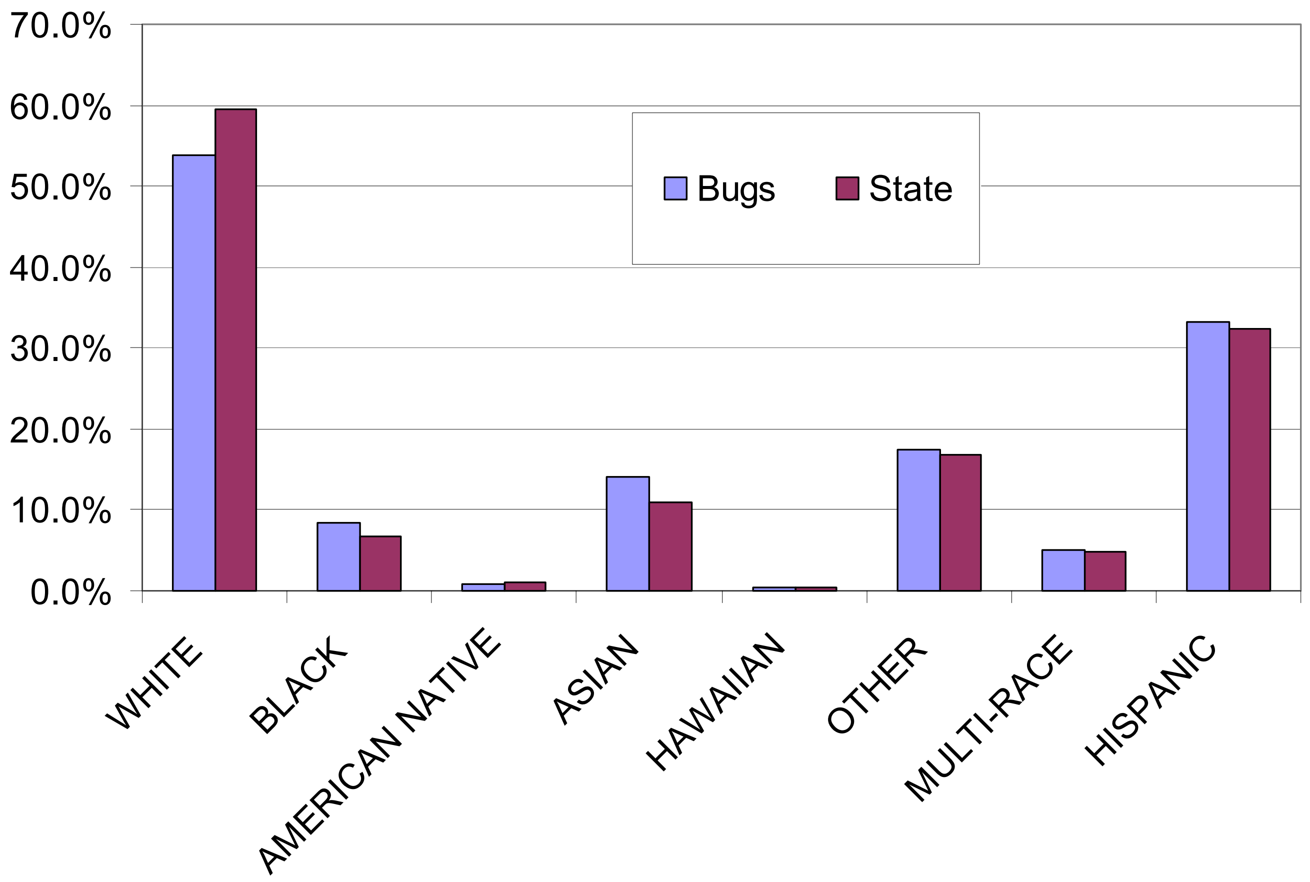
Block Group Population Demographics

Site Specific 1057 kw BUG, Los Angeles



Block Group Population Demographics

State and BUGs -- Race and Ethnicity



Conclusions for dispersion Modeling

- Diesel particulate emissions might exceed acceptable cancer risks.
- Uncertainty in analysis of direct mortality risk.

Modeling

Urban/Regional effects on Ozone

- Federal 1-hr average O3 standard is 120 ppb; the CA State standard is 90 ppb.
- Changes of a few ppb in O3 are significant.
- There are uncertainties in O3 models:
  - Our approach was to evaluate O3 effects using several different models and data sets.
  - Are results insensitive to model uncertainty?
  - Consistency of results among models provides increased confidence in results.

Regional 3-D Air Quality Models

1) SARMAP Air Quality Model (**SAQM**)
   – August 3-6, 1990 CA SIP Episode; 12-km
2) Models 3/Community Multiscale Air Quality (**CMAQ**) Modeling System
   – July, 1996 Western Regional Air Partnership (WRAP) 36-km domain
3) Comprehensive Air Quality Model with extensions (**CAMx**)
   – July 30 – Aug 2, 2000 CCOS episode; 4-km
4) CMAQ application for Black-out episode
   – August 3-7, 1997 SCOS episode

Modeling

Formation of Ozone

- Production of O_3 in the troposphere occurs almost exclusively by the photochemical oxidation of organic compounds in the presence of NO_x:

$$\mathbf{VOC + NO_x \rightarrow O_3}$$

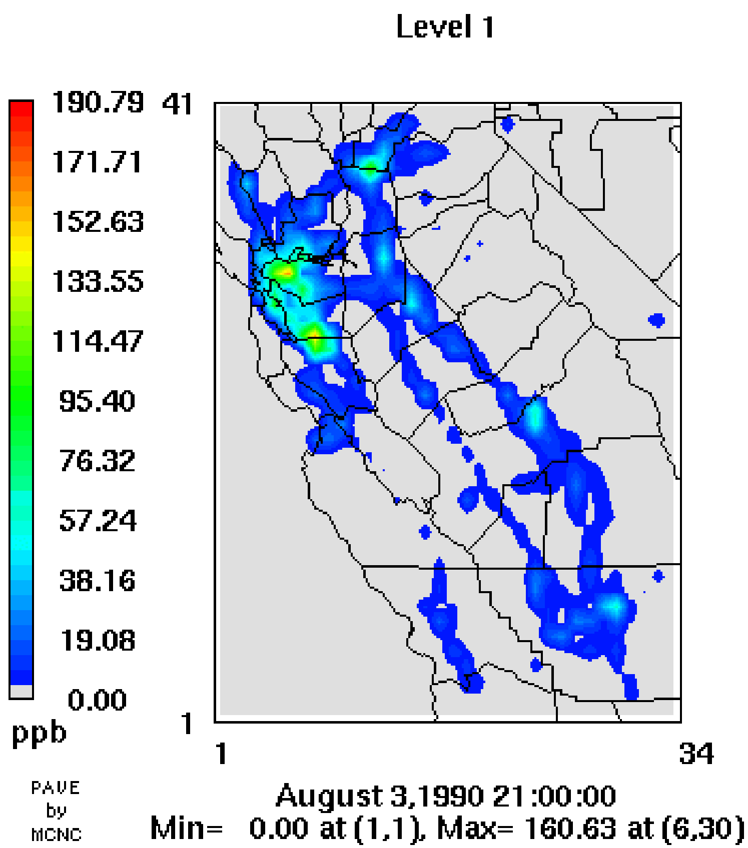
- The NO_x disbenefit:
  - Large NO emissions increases can initially inhibit O_3 production near the source, and then accelerate O_3 production farther downwind:
    - $O_3 + NO \rightarrow NO_2$;
    - $NO_2 + OH \rightarrow HNO_3$

SARMAP 1990 Model datasets

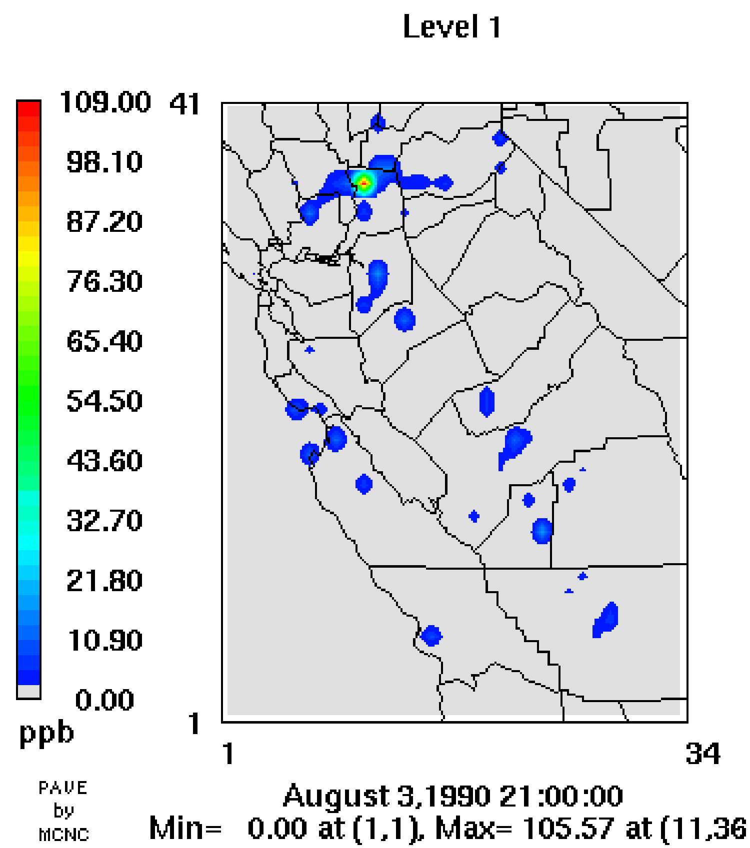
- UCR used data sets produced by ARB for SIP modeling:
  - Emissions compiled by ARB (Damassa et al. 1996 report)
  - Mesoscale Model v 5 (MM5) applied by ARB

SAQM NOx Emissions

Base Case NOx Emissions

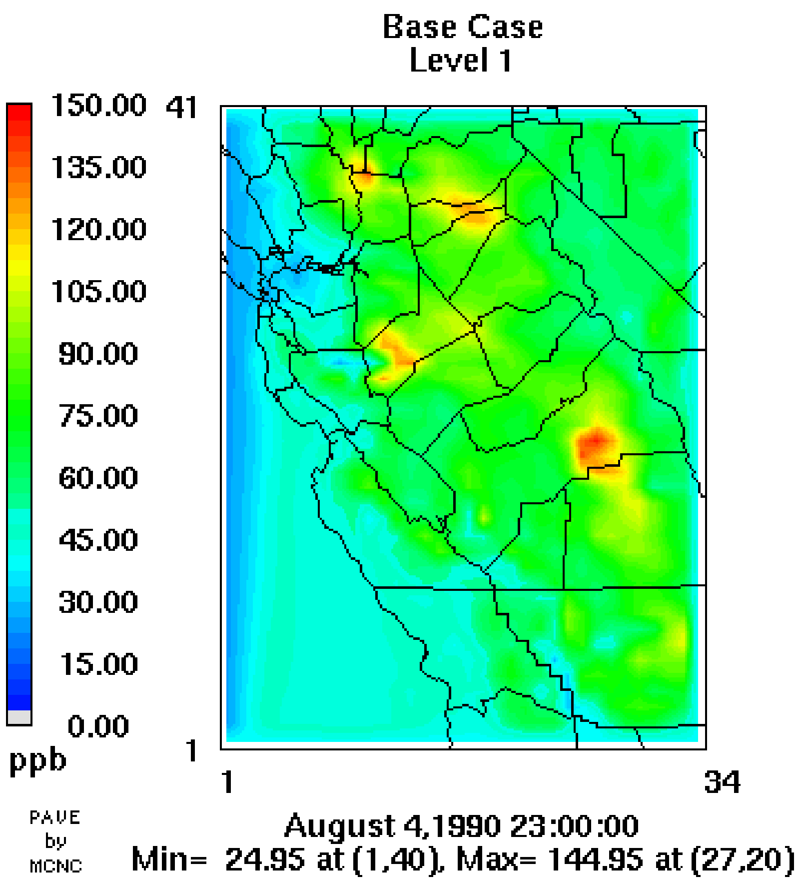


BUGs NOx Emissions

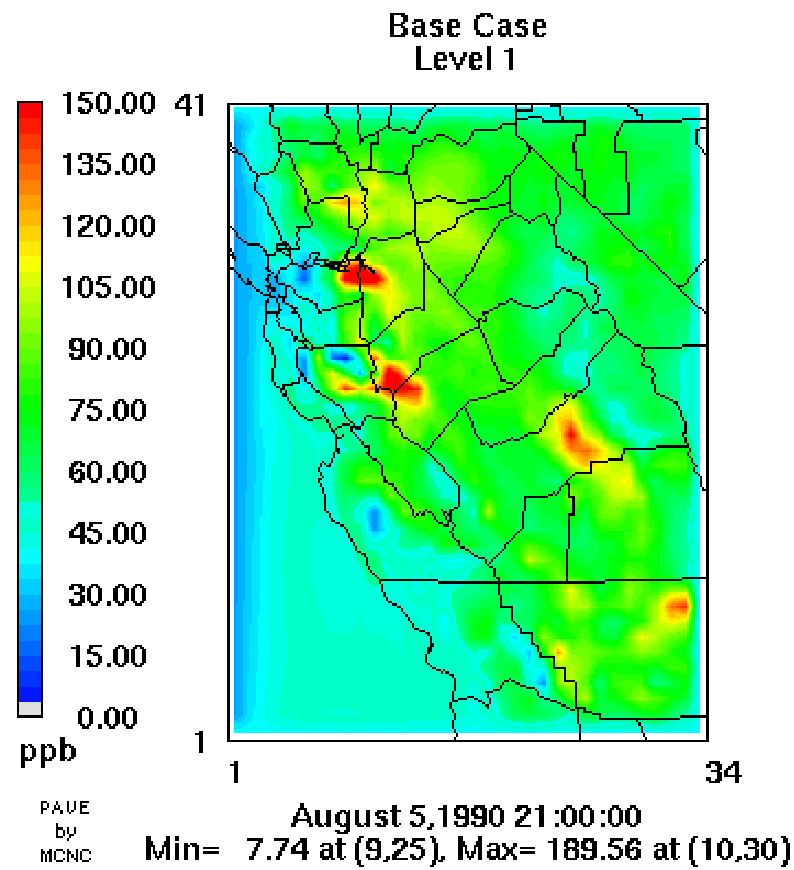


SAQM Model Results – Base Case Aug 4,5

Hourly Average Ozone Conc.

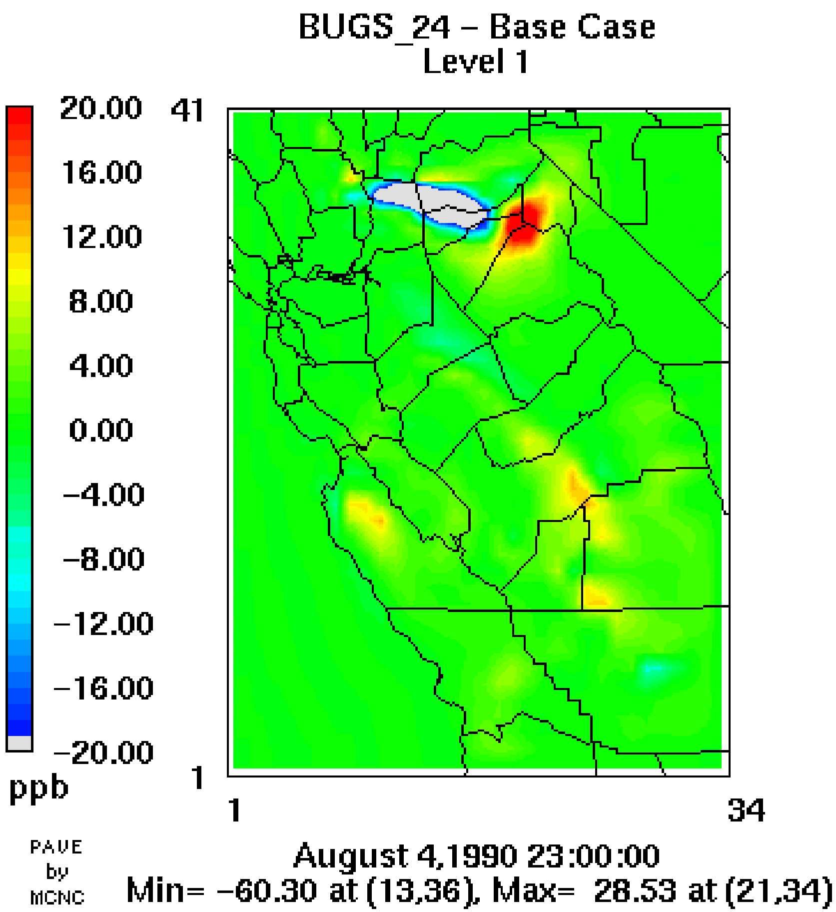


Hourly Average Ozone Conc.

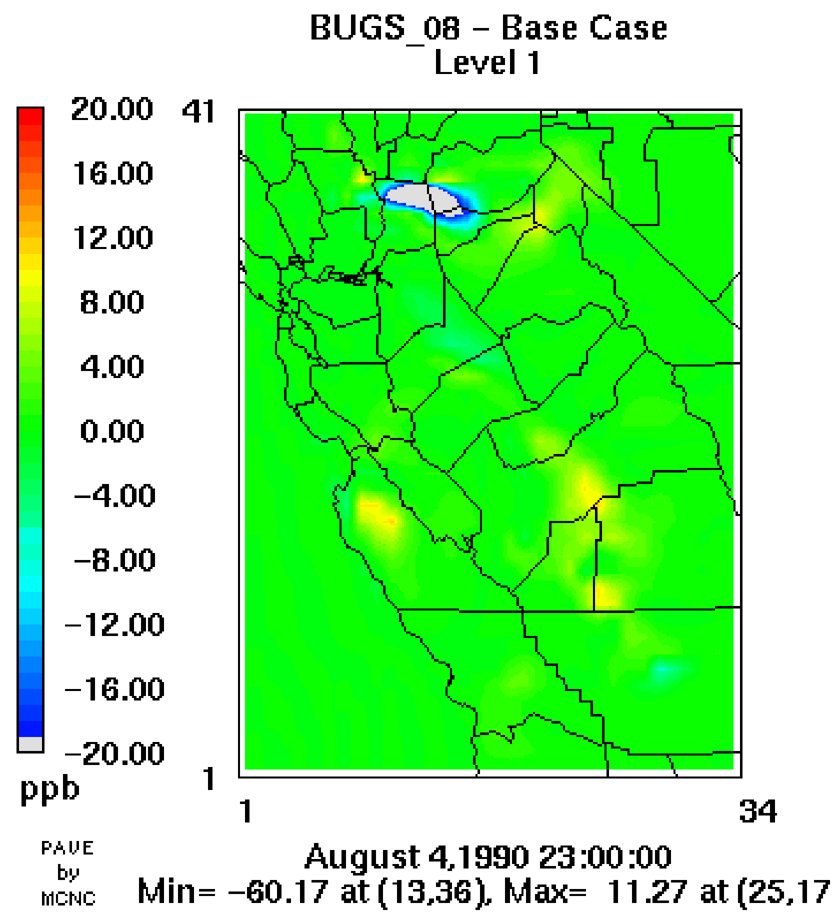


SAQM Model Results

24 Hour operation
Hourly Ozone Difference



8 Hour operation
Hourly Ozone Difference



CAMx scenario for CCOS 2000

- MM5 developed by NOAA
- Emissions developed by ARB
- 4-km resolution model
- Larger population of BUGs but lower emissions factors compared to the SAQM modeling.
- Smaller O3 increase than simulated in the SAQM 1990 modeling:
  - 6 ppb O3 increase in the 8 hour BUGs schedule
  - 12 ppb O3 increase in the 24-hr BUGs schedule

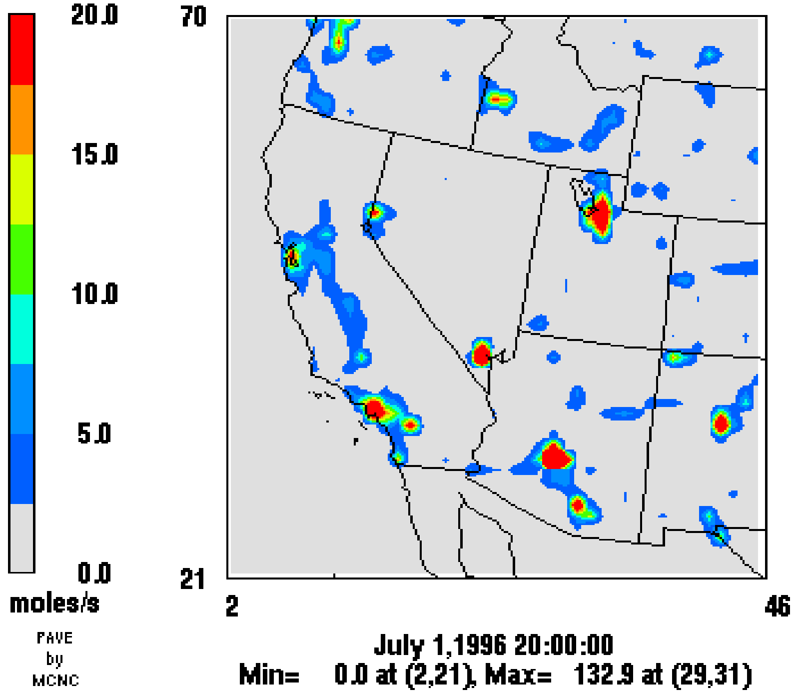
CMAQ Model Inputs

- Developed for Regional Scale Visibility Modeling
- Meteorology
  - Generated using MM5
- Emissions
  - Based upon version 3.11 of the 1996 National Emissions Inventory (NEI) with ma
  - Mobile5b for mobile emissions, EMFAC for CA mobile emissions
  - BEIS2 used for biogenic emissions

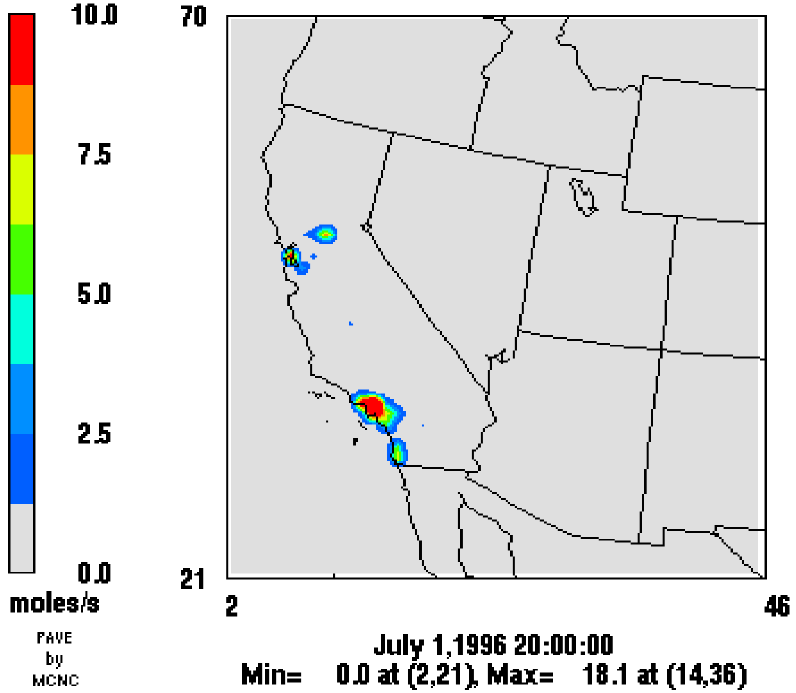
CMAQ NOx Emissions

Base Case NOx Emissions

Layer 1 at 1 PM PDT



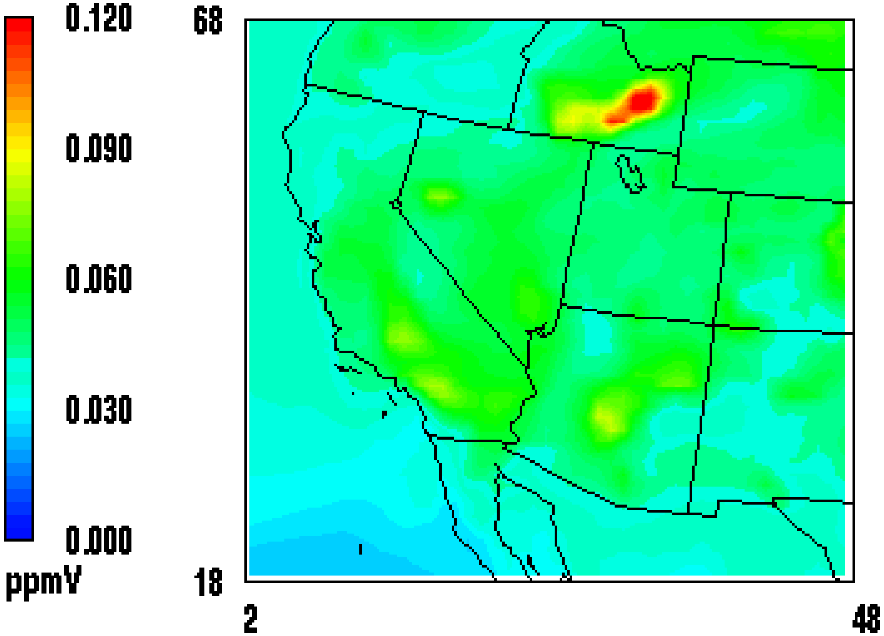
BUGs NOx Emissions



CMAQ O3 Results on July 5

Layer 3 Ozone

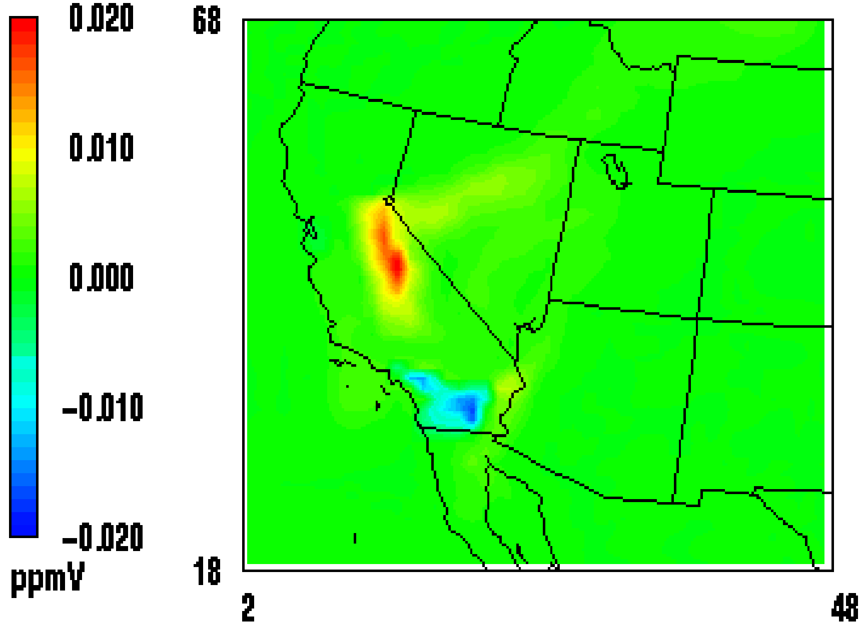
Base Case Scenario



July 5,1996 0:00:00
Min= 0.025 at (4,18), Max= 0.127 at (32,61)

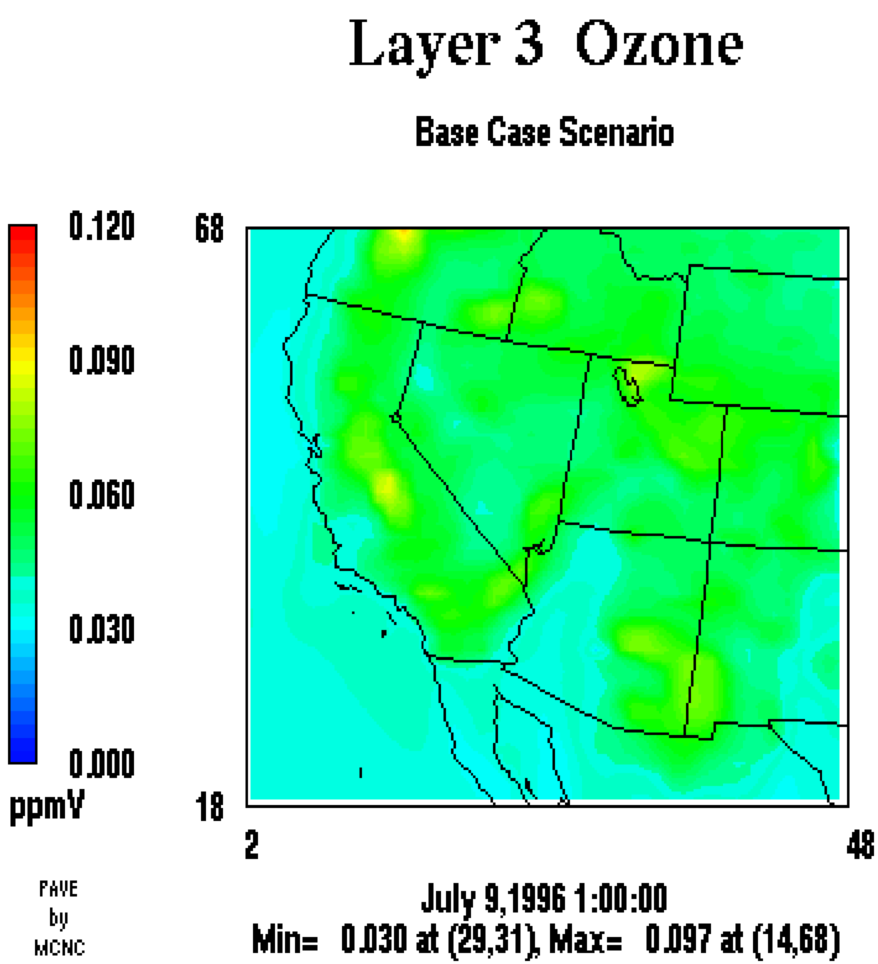
Layer 3 Delta Ozone

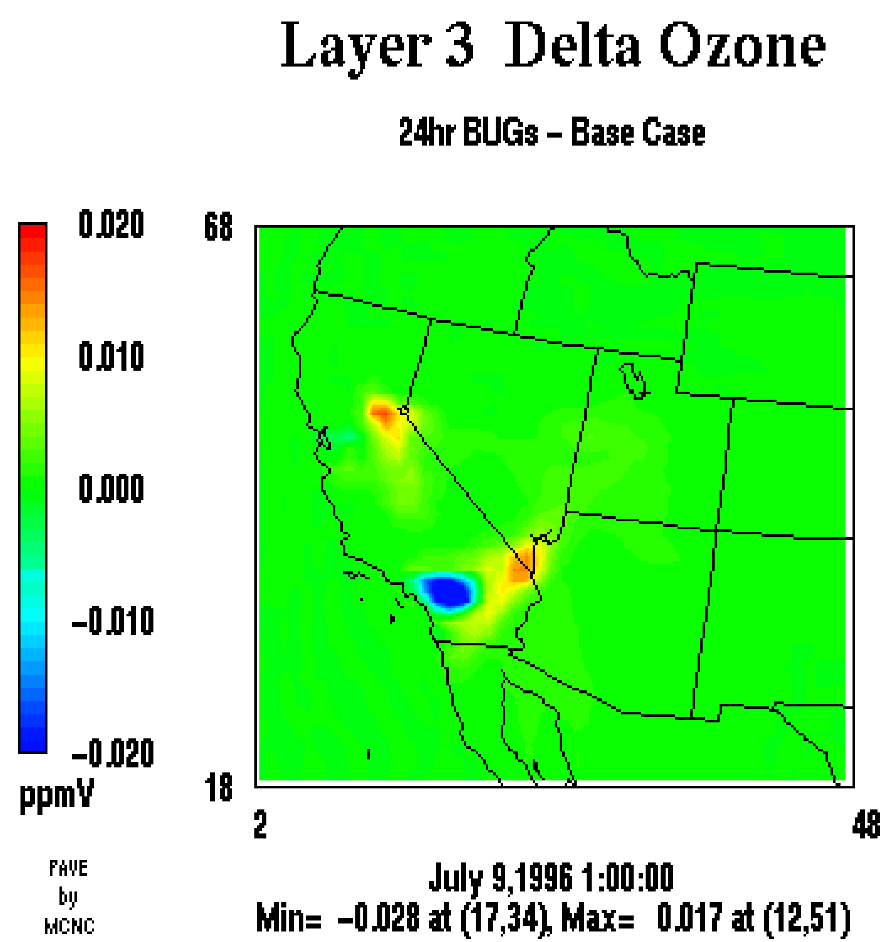
24hr BUGs – Base Case



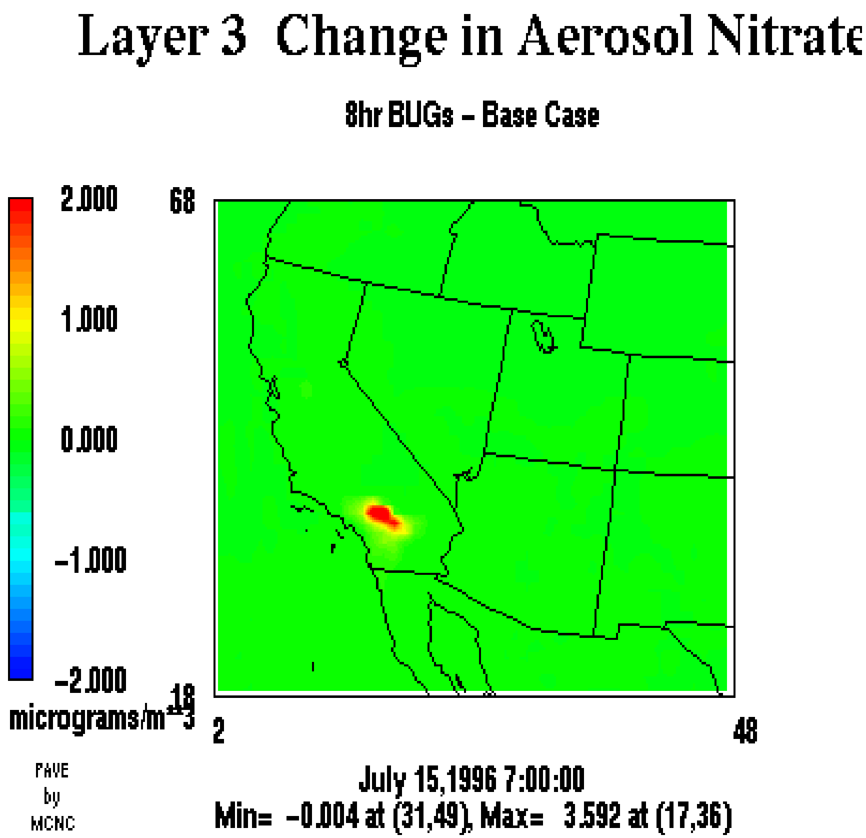
July 5,1996 0:00:00
Min= -0.016 at (20,32), Max= 0.020 at (14,45)

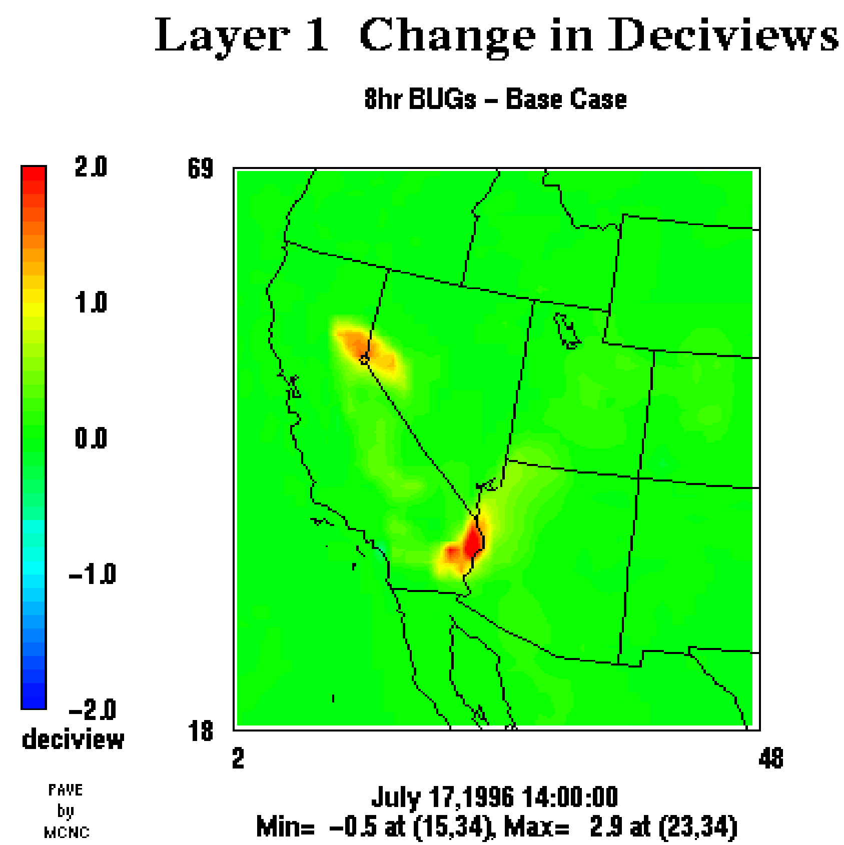
CMAQ Results – O3 on July 9





CMAQ Model Results – other Impacts



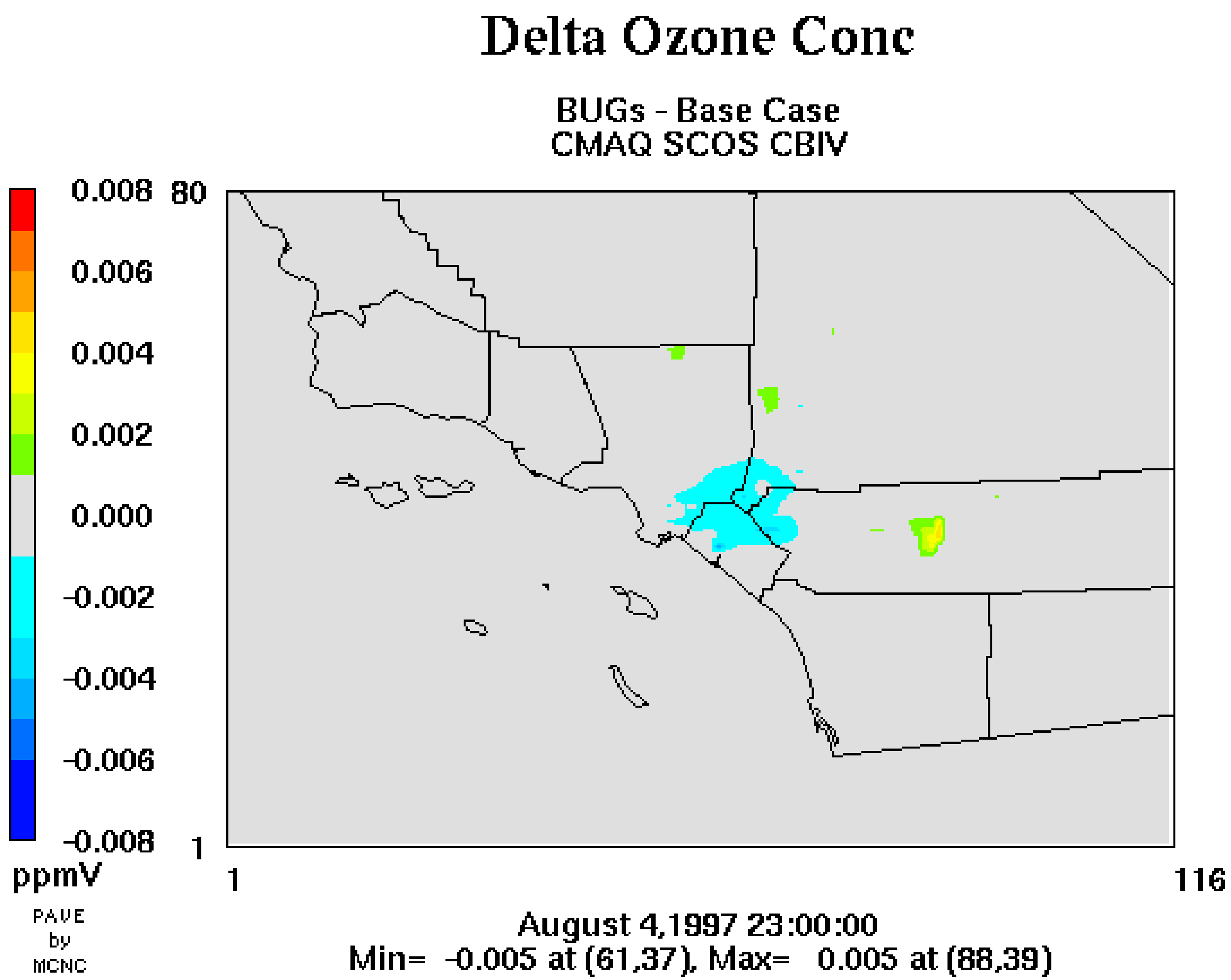


O3 modeling for black-out event

- Actual blackout event was May 8, 2001
- We evaluated hypothetical effects of an identical blackout on a high O3 day.
- Used a CMAQ model scenario developed by ARB for southern CA for Aug 1997
  - 5-km resolution model
  - Emissions and MM5 developed by ARB

Modeling

O3 response to black-out event



Conclusion – Modeling

- In southern CA photochemical modeling shows inhibition of local O3 (i.e., NOx disbenefit) but elevated O3 down wind.
- In central CA there are smaller NOx disbenefits and smaller but significant O3 increases downwind
- Increases result primarily from multi day transport
- Transport of O3 and PM and 8 hour O3 are likely to be important issues.
- There are large increases in secondary fine PM and haze, and increased N deposition.